Ice Velocity Mapping of the Great Ice Sheets: Antarctica

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Making Earth System data records for Use in Research Environments (MEaSUREs)

Talk Outline

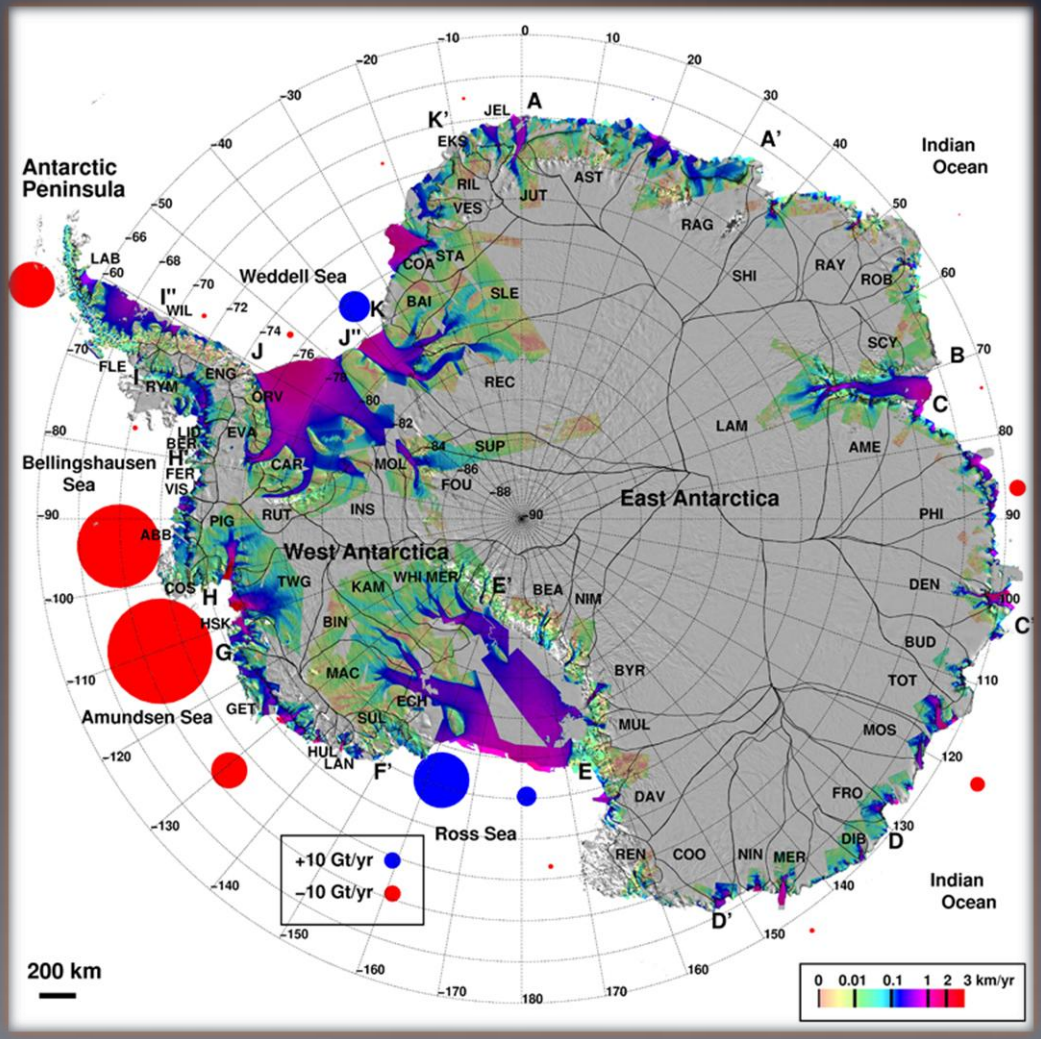
- Motivation
- Goal / Objective / Innovation
- InSAR
- Speckle Tracking
- Discussion of the Input Data
- Production Workflow
- Intermediate Results & Product Description
- South Pol Coverage
- Summary
- Acknowledgements

Motivation

Ice velocity

- is a fundamental characteristic of ice sheet dynamics
- is a critical parameter for numerical ice sheet models

Monitoring ice velocity and its changes over time on a continental scale is important for studying the response of ice sheets to climate change and their global impact on sea level



Rignot et al., Nature Geosc. 2008:
Antarctic mass loss increased from -112 to -196 Gt/yr in 10 years

Goal / Objective / Innovation

- **Goal:** Make ice velocity products available to the scientific community at large to help improve our knowledge and understanding of ice sheet dynamics.

- **Objective:** Generate and distribute a new Earth Science Data Record (ESDR): digital maps of ice velocity of the Antarctic continent from satellite data.

- **Key Innovation:** Continental-scale application of interferometric synthetic-aperture radar techniques.

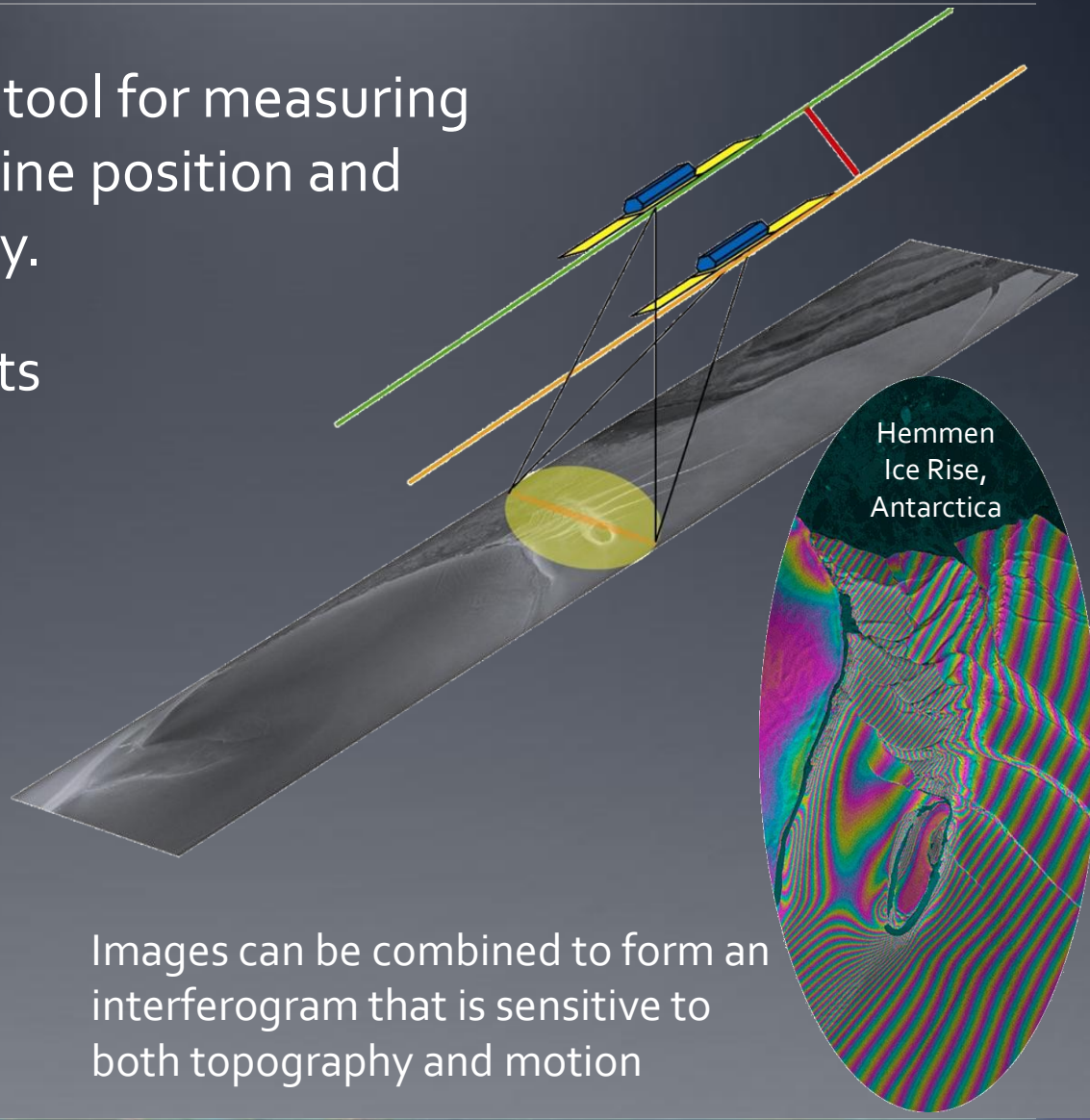
SAR Interferometry (InSAR)

- InSAR is a fundamental tool for measuring ice velocity, grounding line position and their temporal variability.

- Legacy of analysis results
  - ERS-1 (1992)
  - ERS tandem (1996)

  continued with
  - RSAT-1 (1997-2008)

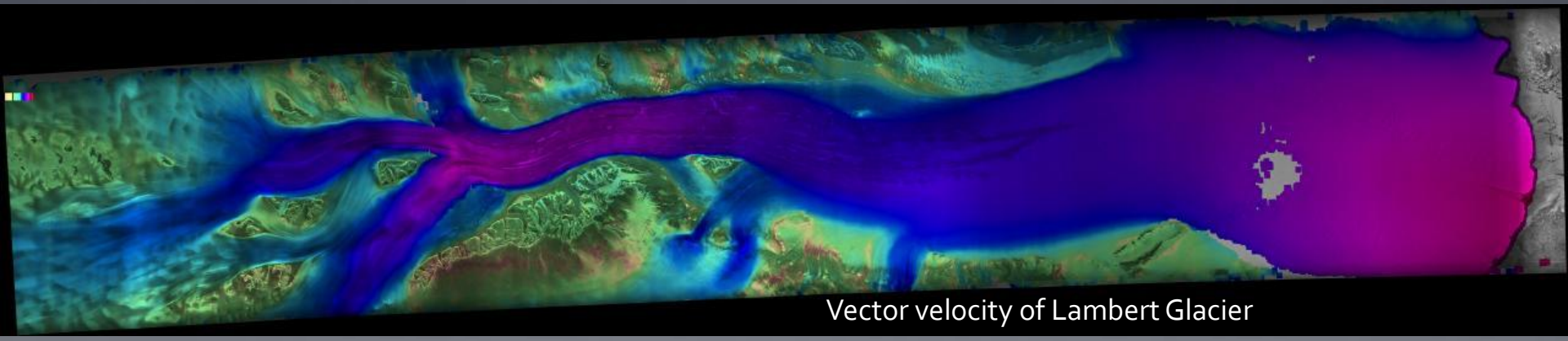
  and now
  - Envisat ASAR
  - ALOS PALSAR



Images can be combined to form an interferogram that is sensitive to both topography and motion

Speckle Tracking

- Longer time periods: speckle tracking (Michel and Rignot, 1999).
- Detect speckle offsets with autocorrelation technique.
- Both x- and y- velocity with a single track.
- Less sensitivity to tidal modulation.



Vector velocity of Lambert Glacier

Input Data

Sensor	Envisat ASAR	ALOS PALSAR	RADARSAT 1
			
Agency	ESA	Jaxa / ASF	CSA / ASF
Band	C	L	C
Revisit	35 days	46 days	24 days
Coverage	2007 / 2008 / 2009	2006★ / 2007 / 2008 ★Part. coverage	1997** / 2000 / 2008
Pro	• Long orbits • Coverage further south than PALSAR	Very good temporal coherence	★★ partial InSAR coverage south of 80° (left looking demo)
Con	Less temporal coherence than L-band (some areas systematically fail)	Ionospheric disturbances in the interior	Less temporal coherence than L-band
Comments	• These satellites were not designed for the task so their use is imperfect • Long repeat cycles make it difficult to map grounding lines		

Data Statistics

Area to be covered: 14 Mio sqkm (1.4 * USA)
→ thousands of scenes to be processed

Single coverage:

- ENVISAT ASAR (~100km swath): 362 orbits
- ALOS PALSAR (~65 km swath): 593 orbits

Scene requirements: minimum 2, preferred 3, 4 even better

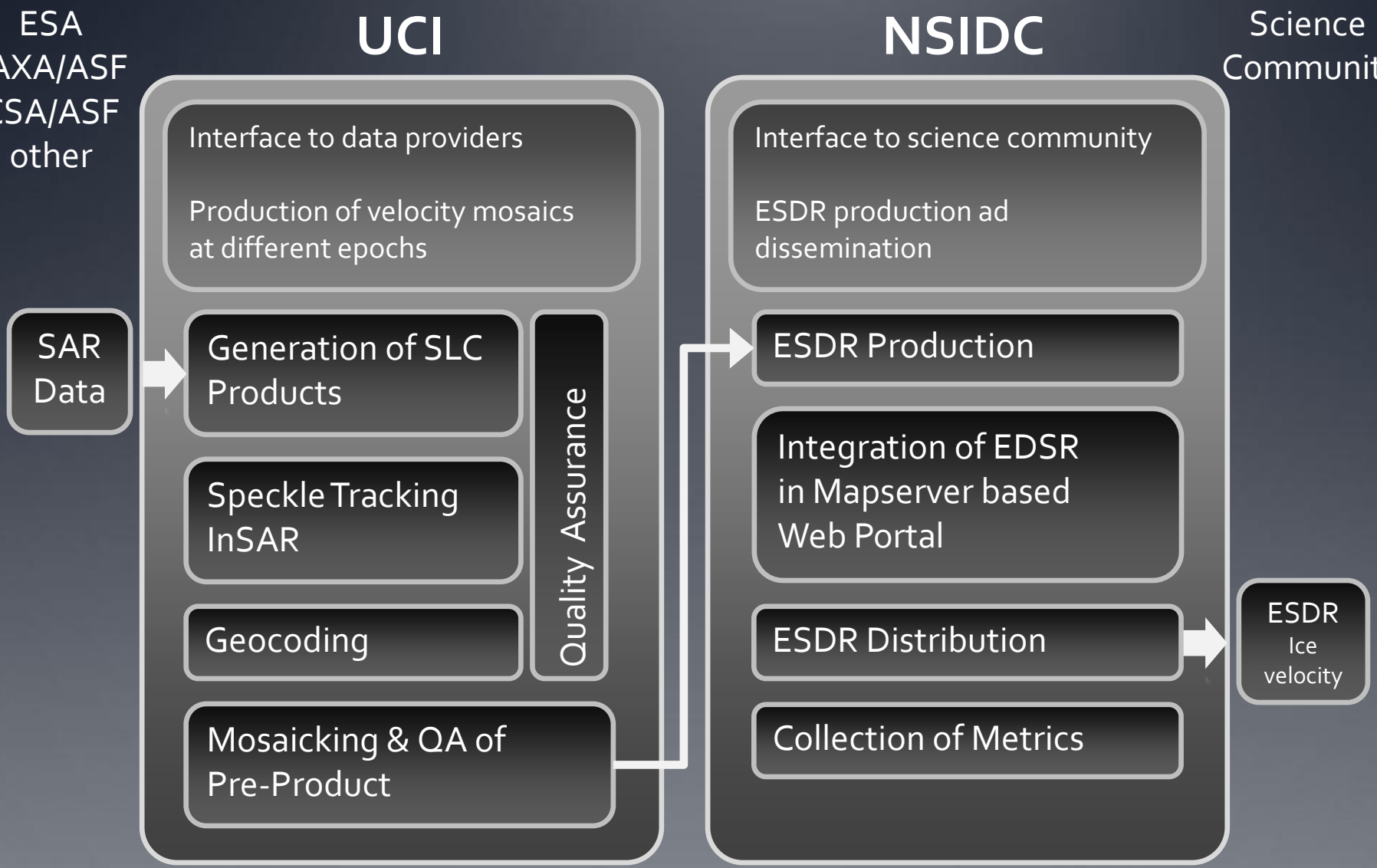
Storage requirements for ALOS PALSAR 2007 coverage:

- RAW radar data: ~ 5,5 TB
- SLC data volume: ~ 22 TB
- Speckle tracking, Geocoding, Mosaicking, Pre-Product: ~ 2 TB

Our process is sensitive to storage requirements and product quality

- Keep source data on disk to allow fast reprocessing
- Keep all required files until QA of a step is passed

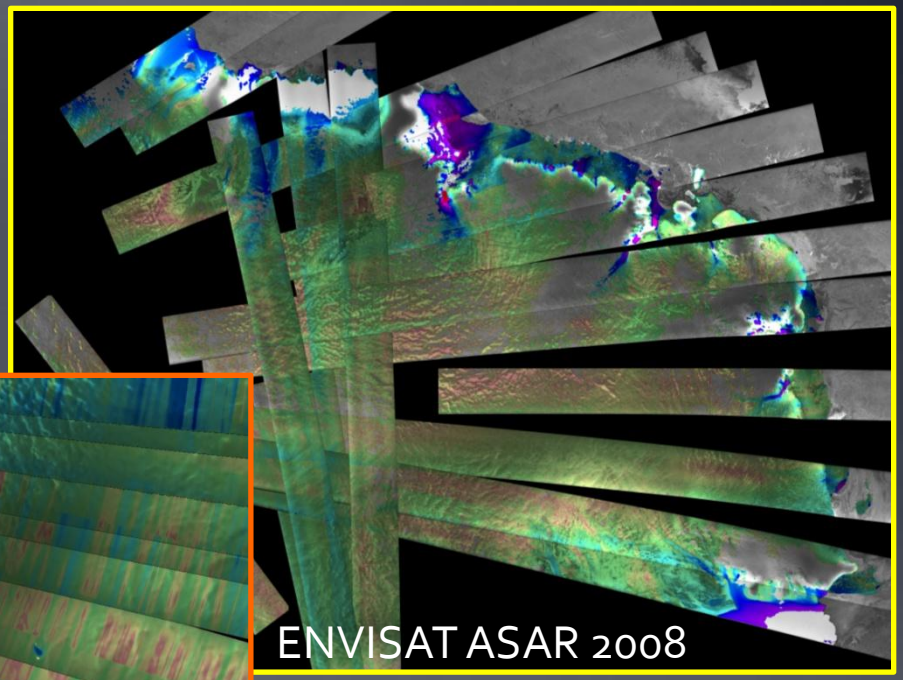
Production Workflow

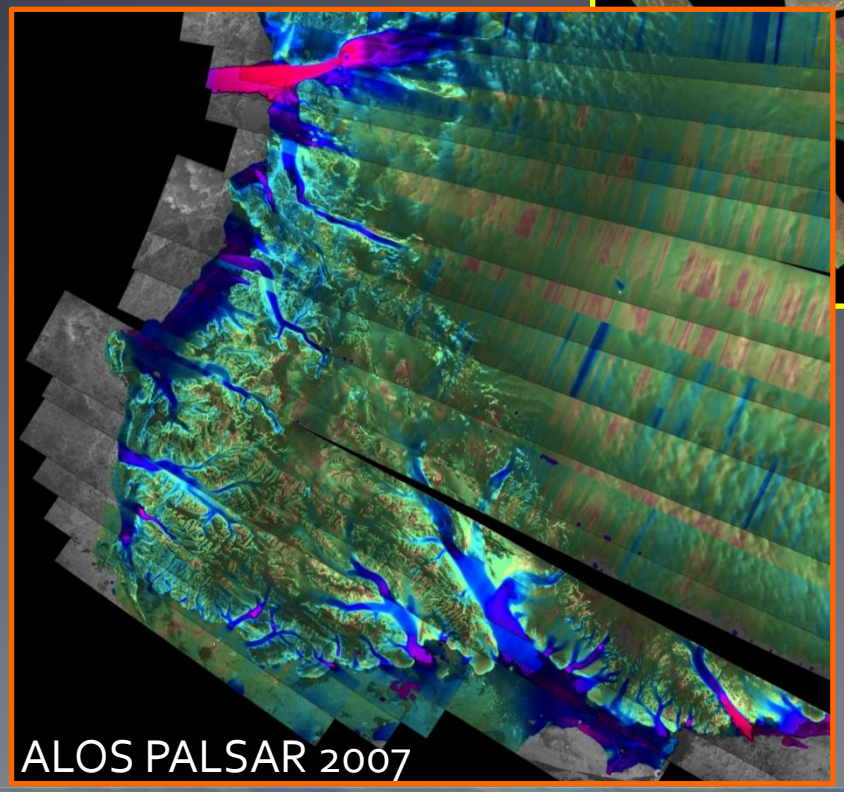


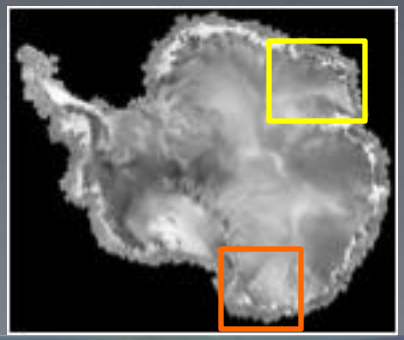
A Product in the Making

Preliminary results of large area processing

Additional calibration steps, multi-sensor fusion, and quality assurance are pending







A new ESDR

ESDR

Final format and structure are under development

- **Information: Ice velocity**
- Posting: 300 m
- Precision:
  - Coastal areas, areas of fast flow: better than 10 m/year
  - Interior: strive for an improvement of the above
- Projection: Polar Stereographic
- Ancillary information: sensor, orbit, frame, date of acquisition, etc.

Delivery Schedule (now entering FY02)

- FY03: Posting of first velocity maps on NSIDC site
- FY04 and FY05: Complete maps for multiple years

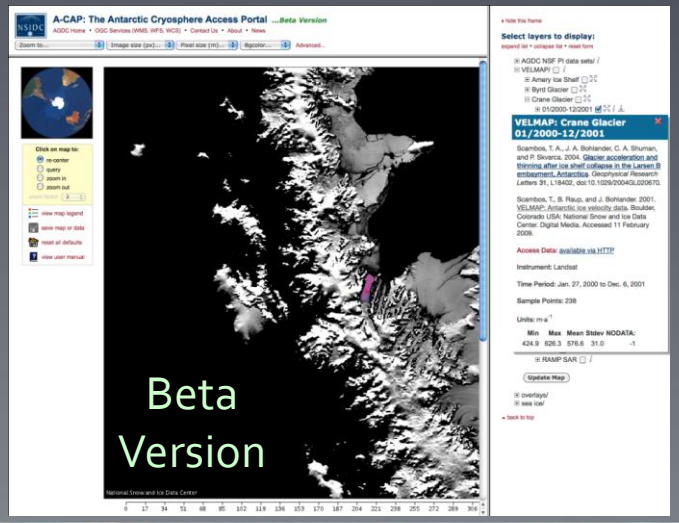
ESDR Dissemination

Distribution of the ice velocity data will be operated by the National Snow and Ice Data Center (NSIDC). For over 30 years NSIDC has managed and distributed scientific data to the cryospheric community.

NSIDC currently distributes several long term data records. Standards created during the development of these data records will be applied to the new ESDR:

- Northern Hemisphere EASE-Grid Weekly Snow Cover and Sea Ice Extent http://nsidc.org/data/nsidc-0046.html
- Sea Ice Index http://nsidc.org/data/seaice_index/

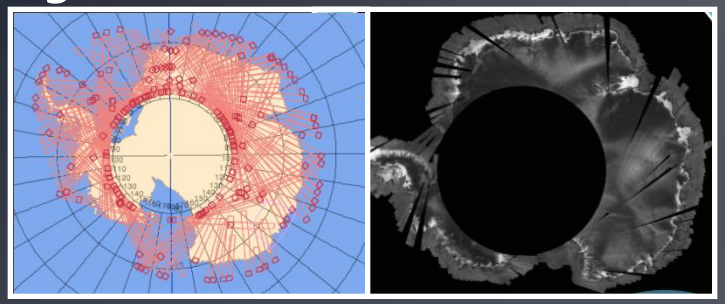
Antarctic Cryosphere Access Portal (A-CAP)
http://nsidc.org/agdc/acap/
A geo-visualization and data download tool developed at NSIDC.



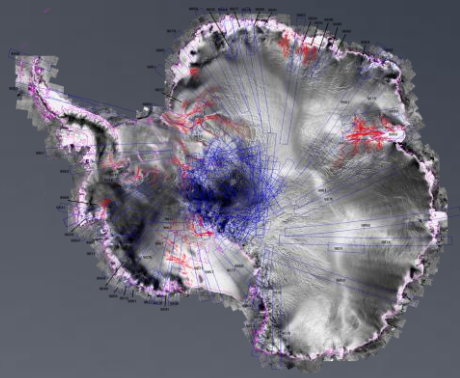
Scambos, Ted, John Maurer, Rob Bauer, Jennifer Bohlander, Terry Haran, and Katherine Leitzell. 2008. A-CAP: The Antarctic Cryosphere Access Portal. Boulder, Colorado USA: National Snow and Ice Data Center. Digital Media. Available at http://nsidc.org/agdc/acap/

Issue: South Pole Coverage

Coverage of the South Pol is an issue for right-looking sensors



- RADARSAT-1
  - dedicated left-looking acquisitions in 1997
  - some interferometric coverage (demonstration)



- RADARSAT-2
  - operational left looking capability
  - Antarctic interferometric mapping mission planned and executed by CSA/MDA this year

- This project and its end product would greatly benefit from access to the RADARSAT-2 Antarctic data!

Summary

- Our goal is to make ice velocity products available to the scientific community at large to help improve our knowledge and understanding of ice sheet dynamics
- We are therefore producing a new Earth Science Data Record (ESDR): Digital maps of **ice velocity** of the Antarctic continent from satellite data (300 m posting with a precision of better than 10 m/year)
- Distribution of ESDR and interface with scientific community will be operated by NSIDC, Boulder CO

Acknowledgements

We would like to thank several agencies for providing massive amounts of data – with considerable cost for the agencies – in support of this project

- JAXA / ASF
- CSA / ASF
- ESA

ESA has modified its new orbit correction strategy for ENVISAT ASAR in support of interferometric Antarctic mapping

Recommendation for data providers:
Continue regular interferometric Antarctic mapping for upcoming years as well as for future missions

Thank You

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